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Describing Behavioral Variability

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Given the concerns that I have about some of the points in this paper, I want to be clear about my high regard for the motivations underlying its development. However, as we develop our science and technology, we must demand of ourselves that we ever more closely approximate the well-developed methodological standards of the mature natural sciences in whose path we follow.

The paper by Powell and Dickie is predicated on some fundamental misunderstandings about the nature of behavioral variability, and they fatally pervade a rare attempt to consider the application of the tactics of dimensional analysis to the phenomenon of behavior. Perhaps the most basic and troublesome of these difficulties concerns the conception of behavioral variability that underlies the paper's arguments about measuring dimensional quantities. It is clear that the authors appreciate the fact that any response class has multiple facets that may be described in terms of distinctive dimensional quantities (customarily called, simply, quantities; see Johnston & Pennypacker, 1980, chapter 7; Johnston & Hodge, 1989). They seem to view a response class as a unitary whole when considering how to describe its variability. They take the unusual position that when a response class is influenced by some variable, its different quantities should co-vary in a unitary manner.

In fact, any relation or contingency between some variable and a particular behavior is actually between the variable and one or more specific quantities that characterize the behavior. Thus, we misspeak when we say that a reinforcer is contingent on a certain behavior. It is more correct to refer to the particular dimensional quantities of the response class whose values can satisfy the contingency's requirements. For example, timed versus untimed class quizzes establish different contingencies between a student's performance and the reinforcing effects of his or her scores. The contingency established by untimed quizzes is presumably between the accuracy of reading and answering questions and the quiz score; whereas, the contingency established by timed quizzes is probably between both the accuracy and the duration of reading and answering questions and the quiz score.

Dimensional measurement of behavior therefore faces the investigator with the decision of which of behavior's many quantities (which number more than the few mentioned by Powell and Dickie) to select for measurement and analysis. The ideal strategy is to measure those quantities in which variability will help answer the experimental question. Variability in the remaining quantities might occasionally lead to serendipitous discoveries, but they will often be irrelevant or not usefully interpretable. Although the importance of certain quantities for a response class will sometimes be obvious from the literature, previous experience, or the nature of the experimental situation, the investigator often cannot be sure in which quantities interesting variability may appear. When this is the case, the only safe tactic is to measure all relevant quantities, at least initially, eventually abandoning those that are unrevealing.

This was the course chosen in our research program concerning rumination. Not knowing what aspects of ruminating might be affected by various independent variables, we began by examining both rate and duration measures (Rast, Johnston, & Drum, 1984; Rast, Johnston, Drum, & Conrin, 1981). After determining that our procedures did not differ-

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entially affect these two quantities, we stopped measuring duration (e.g., Rast, Johnston, Ellinger-Allen, & Drum, 1985).

Powell and Dickie err in viewing a lack of covariation in multiple quantities of a response class as a problem. There is no general reason why quantities such as overall rate and duration should be affected in the same way by a variable or procedure (e.g., Margulies, 1961), and, contrary to the authors' arguments, these two quantities are independent under most circumstances (Johnston & Hodge, 1989). In fact, such discrepancies should be viewed as potentially interesting and valuable discoveries. The appropriate conclusion in these circumstances would be that the independent variable has one kind of effect on the rate and another on the duration of responding. Attempting to draw a unitary conclusion about the effect on the response class as a whole (instead of about the effects on different dimensional quantities of the class) simply misunderstands the nature of behavioral variability. Thus, the paper's otherwise reasonable search for an illuminating derived quantity (K_o, although it should probably be O_k) is improperly motivated by desire to avoid measuring multiple quantities that might present the investigator with evidence that the independent variable has differential effects on these quantities.

A further and related confusion concerning variability is evident in the authors' attempt at dimensional analysis. The goal of the authors' derivation of K_o is described as a search for stability or orderliness in the data it yields; and its tentatively proposed superiority over the "rate" and "duration" constructions in the data sample provided are based on this criterion. Unfortunately, the cardinal scientific standard of order is misapplied in this role. The orderliness or stability of data properly guides our evaluation of the relationship between independent and dependent variables. When responding is stable under a relatively constant set of conditions (either across repetitions within a session or across sessions within a phase), we may tentatively conclude the existence of a certain relationship between the environment and behavior. This inference is at the heart of repeated measures or within subject comparisons in the study of behavior. The orderliness of data is therefore not so much a goal as a guide, telling us when we need to control extraneous variables, revise measurement procedures, vary aspects of the independent variable, or propose that we have identified a functional relation (Johnston & Pennypacker, 1980; Sidman, 1960).

However, this is not the context in which this criterion is invoked in this paper. Instead, the authors attempt to apply the standard of orderliness in the context of descriptive measurement as a way of deciding if data are meaningful or useful or if one quantity is better than another. This application almost reverses the customary role of variability and is quite dangerous to sound inferences. When measuring behavior (or any other phenomenon), the goal is to represent accurately the true state of nature, whatever its variability. When designing behavioral measurement procedures, it is critical to do nothing that might infringe on drawing a complete and accurate picture of responding, lest this then limit accurate interpretations. If the obtained data are unacceptably variable, then this knowledge can guide steps to reduce variability by manipulating the factors of which it is a function. Attempting to "reduce" variability (actually, only the evidence of it) by any measurement procedure that in some way limits one's knowledge about it is counterproductive. Constraining clear access to variability by selecting quantities that are likely to be maximally stable only reduces any opportunity to use variability to guide experimental and interpretative practices. Thus, any value of K_o does not lie in its putative ability to provide a descriptor of behavior that is generally more stable than duration or rate. The potential value of K_o or any other derived quantity comes from the possibility of revealing important and useful aspects of behavior that would not be detected with rate, duration, or other traditional quantities.

Aside from its problems with variability, the paper embodies a variety of other difficulties that must be identified. One of these concerns the topic of dimensional analysis, which is not well represented here (a brief description of this tactic may be found in Johnston & Hodge, 1989; also see Barenblatt, 1987). Dimensional analysis is largely used in the natural sciences as a method of obtaining suggestions about meaningful relationships that may exist in a phenomenon. It is a technique for deriving dimensionless numbers that may guide a search for physical relationships. Although dimensional analysis may begin with deriving compound quantities that combine fundamental quantities in new relationships, any supposed relationship must be confirmed by experimental analysis. Furthermore, dimensional analysis will not lead to the discovery of basic laws.

Unfortunately, the discussion of the relative characteristics of K_0 compared to rate and duration is flawed by the data used in the analysis. Ignoring potential problems of response class definition (stereotypic and attending "behaviors" may well have been broad categories subsuming diverse functional response classes), the discontinuous measurement procedure used (a variation of interval recording) guarantees that the data represent neither rate nor duration. It is, by definition, not possible to "transform" the data resulting from the reported measurement procedure into rate and duration data. Calculating rate requires counting the number of cycles of a response class during a period of continuous observation and dividing this number by either the total time of observation or the total interresponse time (see Johnston & Hodge, 1989, for a discussion of these alternatives). Calculating aggregate duration requires summing the time between the beginning and the end of each response during a period of observation. Neither quantity can be calculated from the reported data, and estimates are both unnecessary and unacceptable in this context.

There are other miscellaneous problems that should be argued; the following is an incomplete list. 1) $N/(D \times T)$ does not define response acceleration. Assuming that T is defined by total session time (which is not clear), D and T represent behaviorally different "kinds" of time and violate the usual meaning of acceleration (Johnston & Hodge, 1989). 2) References to "levels" of behavior or "levels" of analysis of behavior are misleading when they merely refer to analyzing different fundamental or compound quantities. 3) The coefficient of variation is a risky general metric of variability (in the natural sciences it is used as an indicator of the precision of measurement) because it involves the mean in its calculation, a potential problem when there is any correlation between the mean and the standard deviation (Johnston & Pennypacker, 1980, chapter 17). 4) The comparison of K_0 with rate and duration fails to offer correlations, which would be useful in showing the extent to which a new, derived quantity reflects variability that existing quantities do not. 5) Finally, under the weight of some of the criticisms described in this review, the expansive role suggested for K_0 seems inappropriate.

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